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Morizaki et al.

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(54) **PROTECTION DEVICE, IMAGE FORMING APPARATUS AND METHOD, AND NON-TRANSITORY COMPUTER READABLE MEDIUM**

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H02H 9/04 (2006.01)

(52) **U.S. Cl.**
CPC . ***G03G 15/80*** (2013.01); ***H02H 9/04*** (2013.01)

(58) **Field of Classification Search**
USPC 361/93.9; 399/37
See application file for complete search history.

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(57) **ABSTRACT**

A protection device includes a pair of electrodes and an output unit. In the pair of electrodes, one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, performs discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state. The output unit detects discharge current that flows in the other electrode and outputs the detected discharge current as a control signal.

10 Claims, 9 Drawing Sheets

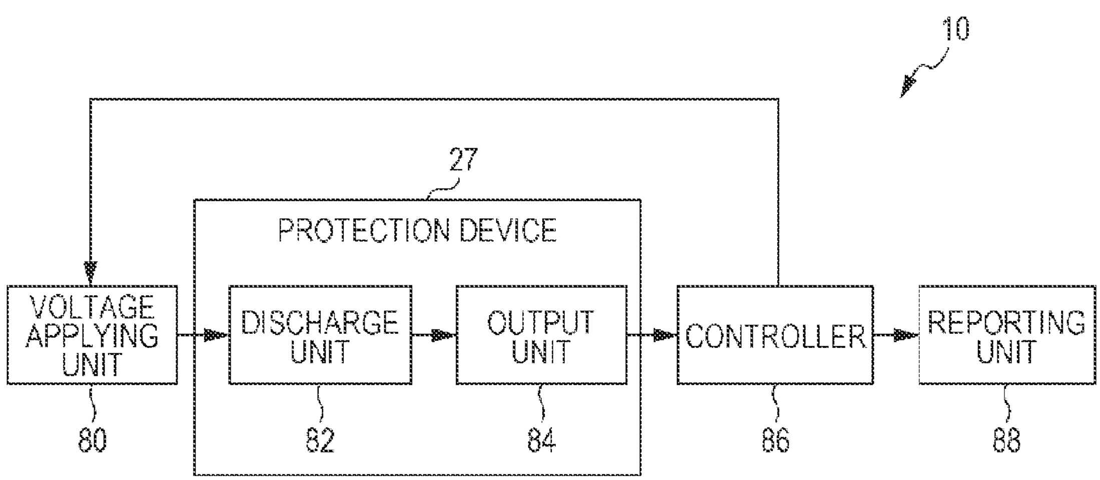


FIG. 1

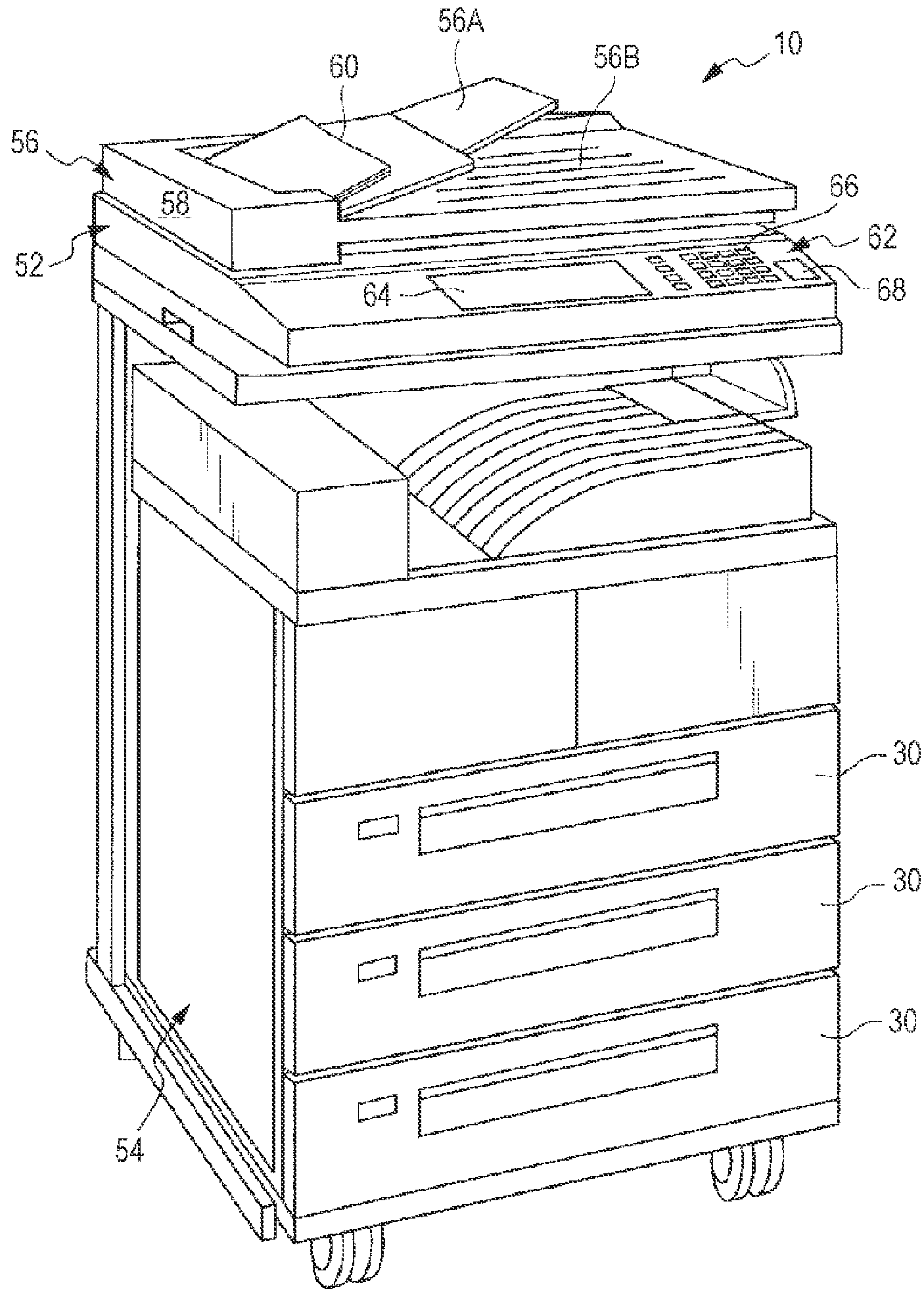


FIG. 2

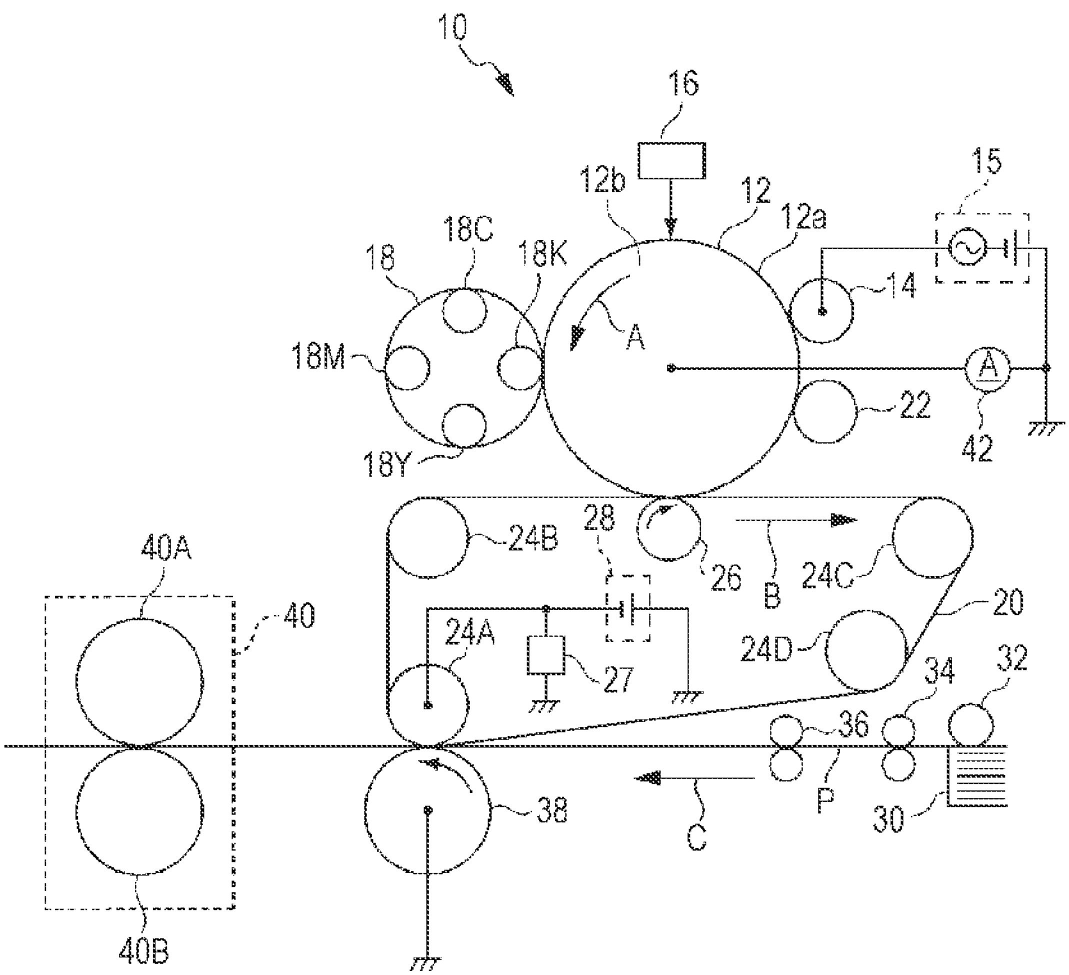

10
16
15
12b
12
12a
18C
18
18K
14
A
18M
A
22
42
18Y
28
24B
26
B
24C
40A
20
40
24A
24D
34
32
27
36
P
38
C
30
40B

FIG. 3

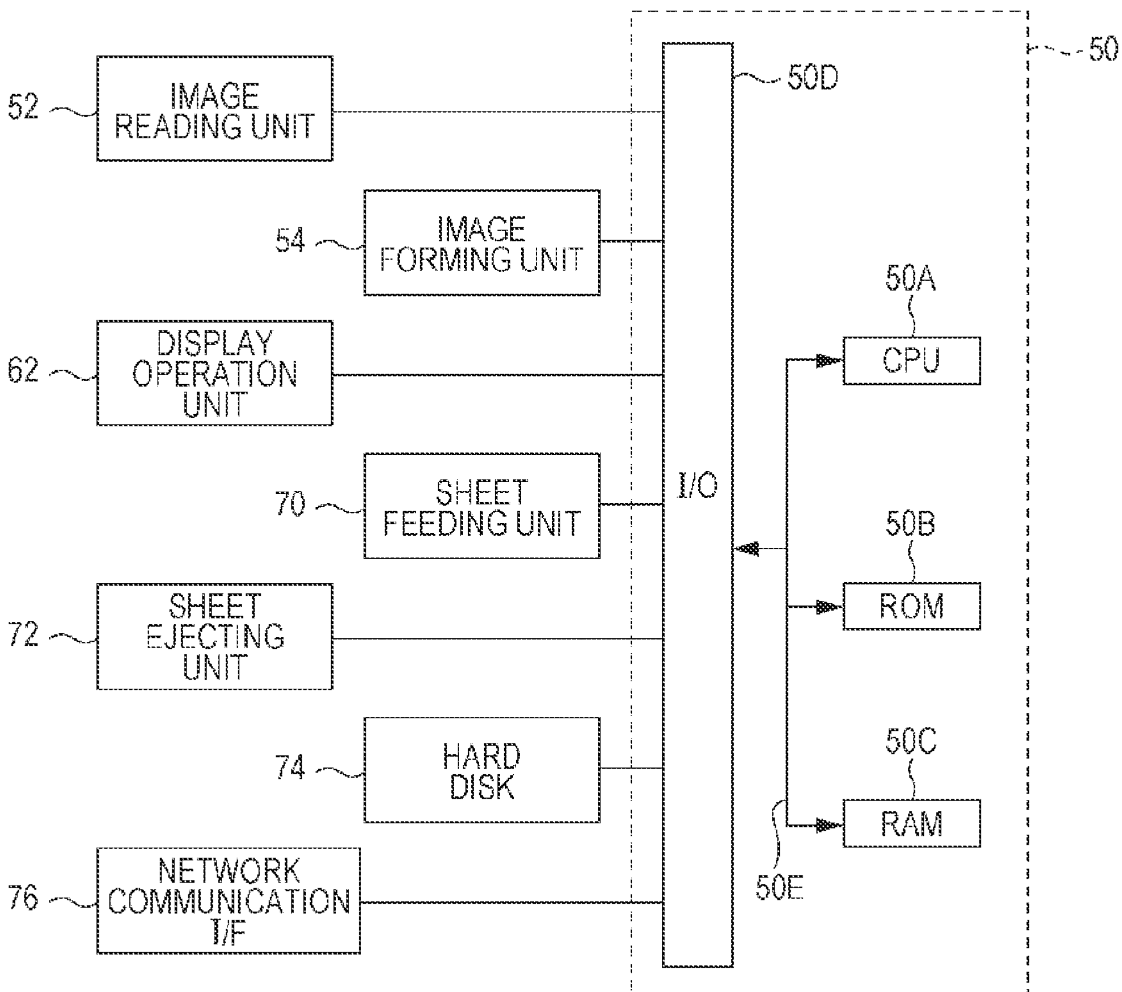
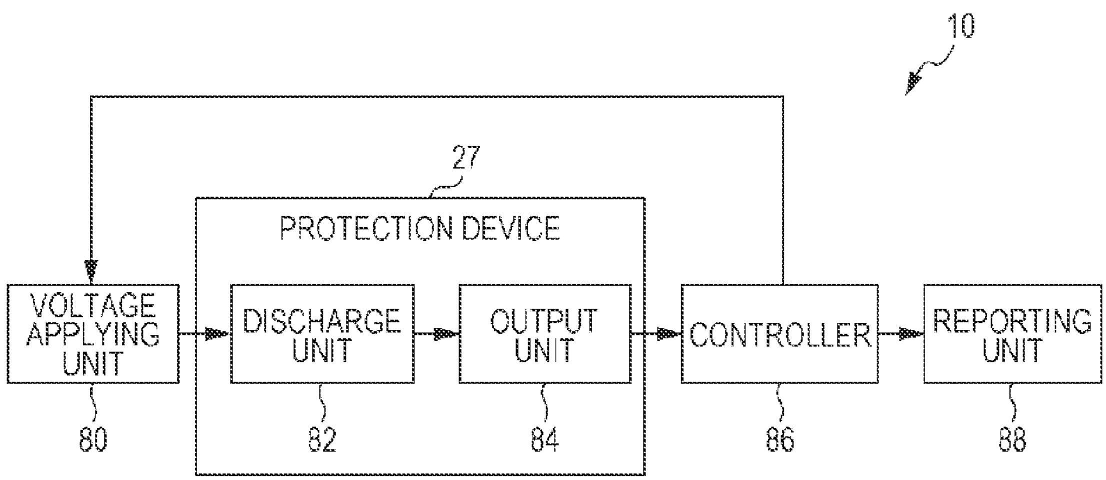

50
50D
52
IMAGE READING UNIT
54
IMAGE FORMING UNIT
62
DISPLAY OPERATION UNIT
70
SHEET FEEDING UNIT
72
SHEET EJECTING UNIT
74
HARD DISK
76
NETWORK COMMUNICATION I/F
I/O
50A
CPU
50B
ROM
50C
RAM
50E

FIG. 4



10
27
PROTECTION DEVICE
VOLTAGE APPLYING UNIT
DISCHARGE UNIT
OUTPUT UNIT
CONTROLLER
REPORTING UNIT
80
82
84
86
88

FIG. 5

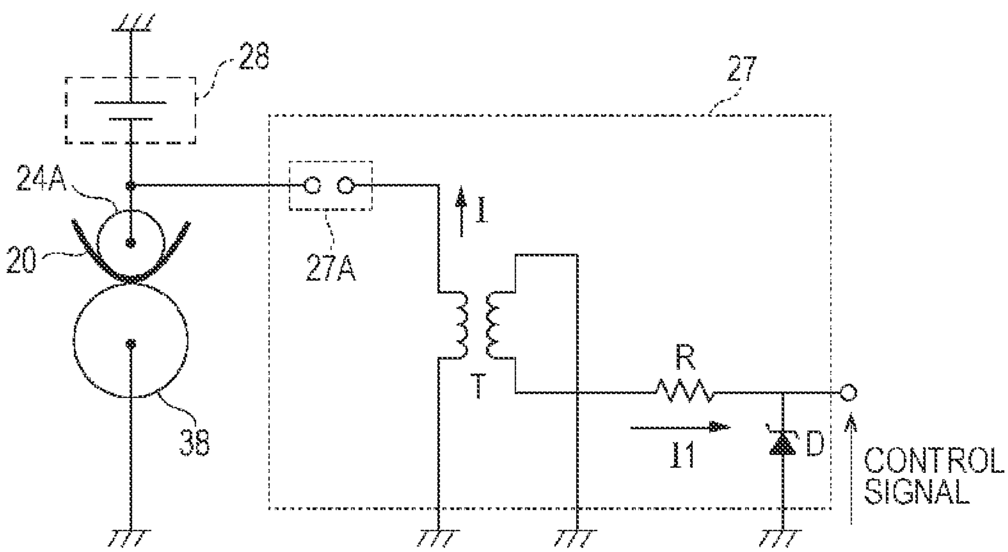
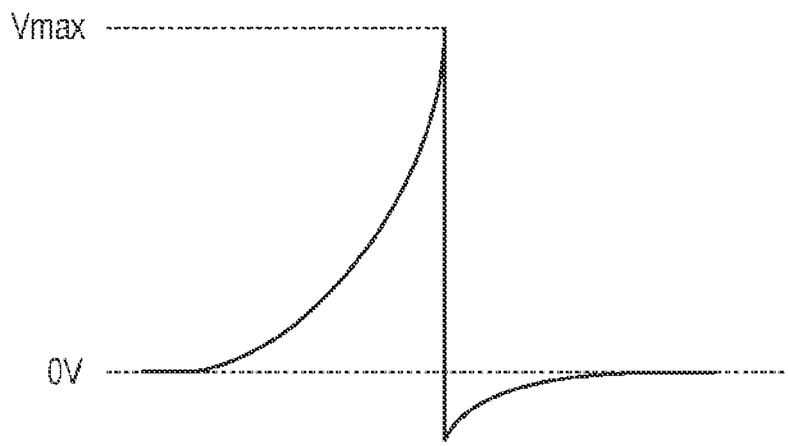


FIG. 6



CONTROL SIGNAL WAVEFORM

FIG. 7A

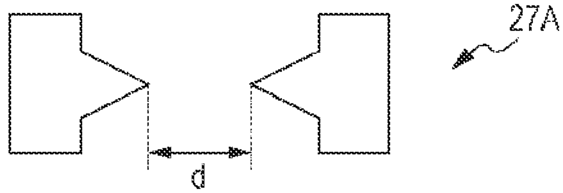


FIG. 7B

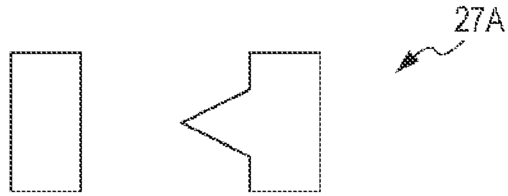


FIG. 7C

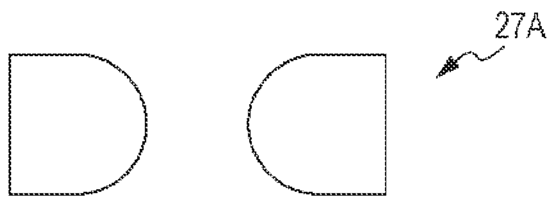


FIG. 7D

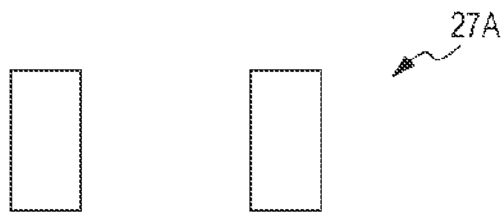


FIG. 7E

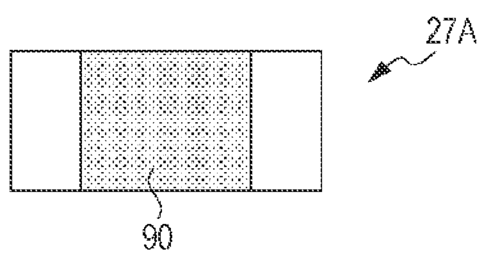


FIG. 7F

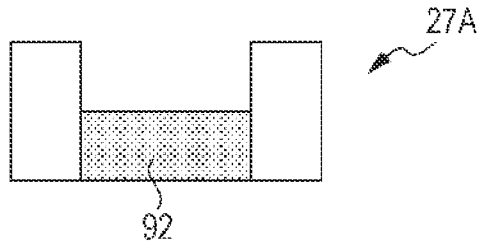


FIG. 8

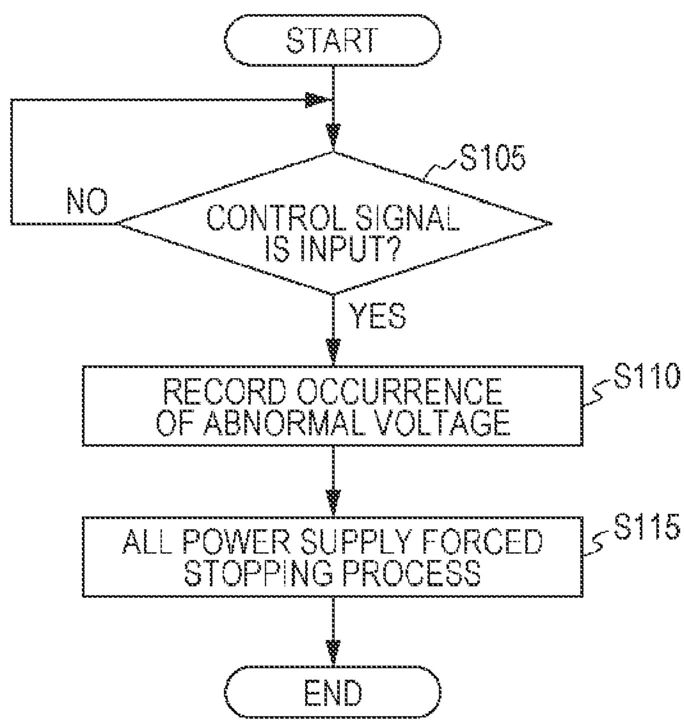
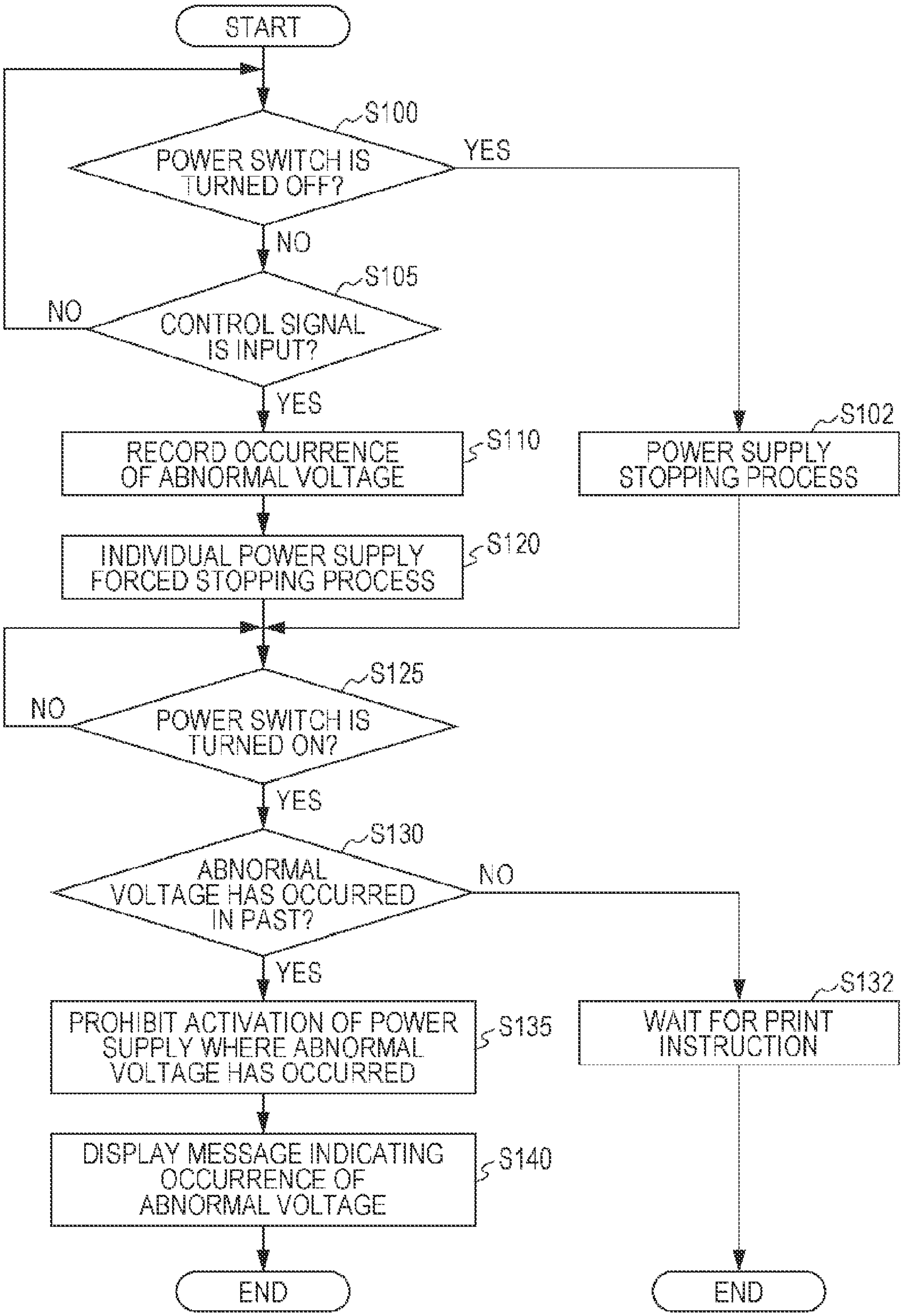

START
S105
NO
CONTROL SIGNAL IS INPUT?
YES
RECORD OCCURRENCE OF ABNORMAL VOLTAGE
S110
ALL POWER SUPPLY FORCED STOPPING PROCESS
S115
END

FIG. 9


START
S100
POWER SWITCH IS TURNED OFF?
YES
NO
S105
CONTROL SIGNAL IS INPUT?
NO
YES
S110
RECORD OCCURRENCE OF ABNORMAL VOLTAGE
S102
POWER SUPPLY STOPPING PROCESS
S120
INDIVIDUAL POWER SUPPLY FORCED STOPPING PROCESS
S125
POWER SWITCH IS TURNED ON?
NO
YES
S130
ABNORMAL VOLTAGE HAS OCCURRED IN PAST?
NO
YES
S135
PROHIBIT ACTIVATION OF POWER SUPPLY WHERE ABNORMAL VOLTAGE HAS OCCURRED
S132
WAIT FOR PRINT INSTRUCTION
S140
DISPLAY MESSAGE INDICATING OCCURRENCE OF ABNORMAL VOLTAGE
END
END

PROTECTION DEVICE, IMAGE FORMING APPARATUS AND METHOD, AND NON-TRANSITORY COMPUTER READABLE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2012-247615 filed Nov. 9, 2012.

BACKGROUND

Technical Field

The present invention relates to a protection device, an image forming apparatus and method, and a non-transitory computer readable medium.

SUMMARY

According to an aspect of the invention, there is provided a protection device including a pair of electrodes and an output unit. In the pair of electrodes, one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, performs discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state. The output unit detects discharge current that flows in the other electrode and outputs the detected discharge current as a control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

FIG. **1** is a perspective view of a major portion of an image forming apparatus according to exemplary embodiments;

FIG. **2** is a schematic side view illustrating the configuration of a major portion of the image forming apparatus according to the exemplary embodiments;

FIG. **3** is a block diagram illustrating the configuration of a major portion of the electrical system of the image forming apparatus according to the exemplary embodiments;

FIG. **4** is a functional block diagram illustrating the functional configuration of the image forming apparatus according to the exemplary embodiments;

FIG. **5** is a schematic diagram illustrating the configuration of a major portion of a protection device according to the exemplary embodiments;

FIG. **6** is a waveform chart of a control signal of the protection device according to the exemplary embodiments;

FIGS. **7**A to **7**F are schematic diagrams provided to describe the shapes of electrodes of the protection device according to the exemplary embodiments;

FIG. **8** is a flowchart of a process executed by a computer of the image forming apparatus according to a first exemplary embodiment; and

FIG. **9** is a flowchart of a process executed by the computer of the image forming apparatus according to a second exemplary embodiment.

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments of the invention will be described in detail with reference to the drawings. Elements and steps that perform activities with the same operations and functions are given the same reference numerals throughout the drawings, and overlapping descriptions may be appropriately omitted.

First Exemplary Embodiment

FIG. **1** illustrates the configuration of an image forming apparatus **10** according to a first exemplary embodiment. The image forming apparatus **10** receives various types of data via a communication line (not illustrated) and has a print function that performs an image forming process based on the received data and a copy function that copies an image recorded on a subject copy to a recording sheet.

An image reading unit **52** is provided in an upper portion of the image forming apparatus **10**. An image forming unit **54** is arranged below the image reading unit **52**. The image reading unit **52** includes a subject copy carrying unit **58** in a subject copy covering part **56**. The subject copy carrying unit **58** sequentially pulls subject copies **60** placed on a subject copy feeding part **56**A provided at the subject copy covering part **56**, and carries the subject copies **60** onto a platen glass (not illustrated). The image reading unit **52** reads image information recorded on the subject copies **60** carried onto the platen glass. Also, the subject copy carrying unit **58** ejects the subject copies **60**, whose image has been read, onto a subject copy ejection part **56**B provided at the subject copy covering part **56**.

The image reading unit **52** includes a display operation unit **62** that accepts various instructions input by operations performed by a user, and displays various types of information of the image forming apparatus **10**. The display operation unit **62** includes a touch panel type display **64** that displays various types of information and display buttons that realize acceptance of instructions input by user operations by using a software program, hardware keys **66** such as a numeric keypad and a start button, and a main power switch **68**. With the use of the display buttons of the display **64** and the hardware keys **66**, the display operation unit **62** is used to set the number of copies and/or a scaling factor when the copy function is used.

The image forming unit **54** forms an image on a recording medium accommodated in a sheet container **30** by using, for example, the so-called electrophotographic system.

FIG. **2** is a schematic side view illustrating the configuration of a major portion of the image forming unit **54** of the image forming apparatus **10** according to the first exemplary embodiment.

As depicted in FIG. **2**, the image forming apparatus **10** includes a photoconductor drum **12** rotated by a motor (not illustrated) in a direction indicated by arc-shaped arrow A, which is a sub-scanning direction, at a predetermined rotation speed. The photoconductor drum **12** includes a photoconductor film **12***a* that is provided on a periphery face and that includes a charge transport layer and a charge generation layer, and a base member **12***b* that supports the photoconductor film **12***a* and that is formed of aluminum or the like.

A charging roller **14** that charges the periphery face of the photoconductor drum **12** is provided on and in contact with the periphery face of the photoconductor drum **12**. Although the charging roller **14**, which is a contact-type charger, is applied in the image forming apparatus **10** according to the first exemplary embodiment, a non-contact-type charger such as a scorotron charger or a corotron charger may be used.

The charging roller **14** is a conductive roller and is configured to be freely rotatable in accordance with the rotation of the photoconductor drum **12**.

Also, voltage generated by superimposing alternating current (AC) voltage and direct current (DC) voltage (hereinafter may also be referred to as "superimposed voltage") is applied to the charging roller **14** from a charging power supply **15**. Accordingly, the charging roller **14** generates discharge at a gap between the charging roller **14** and the photoconductor drum **12** and uniformly charges the periphery face of the photoconductor drum **12** at a predetermined potential. A DC detector **42** is provided in the image forming apparatus **10**. The DC detector **42** detects the value of a DC component caused by the charging roller **14** to flow into the photoconductor drum **12**. Since the superimposed voltage applied to the charging roller **14** is negative in the first exemplary embodiment, the charging roller **14** charges the periphery face of the photoconductor drum **12** at a negative potential.

A laser beam scanner **16** is arranged downstream from the charging roller **14**, in the direction indicated by arc-shaped arrow A of the photoconductor drum **12**. The laser beam scanner **16** modulates a laser beam emitted from a light source, in accordance with an image to be formed, deflects the light beam in a main scanning direction, and performs scanning in parallel with the axis of the photoconductor drum **12**, on the periphery face of the photoconductor drum **12**. Accordingly, an electrostatic latent image is formed on the periphery face of the photoconductor drum **12**.

A developing device **18** is arranged downstream from the laser beam scanner **16**, in the direction indicated by arc-shaped arrow A of the photoconductor drum **12**. The developing device **18** includes a roller-shaped container arranged to be rotatable. Four containing parts corresponding to yellow (Y), magenta (M), cyan (C), and black (K) are formed in this container, and developing units **18**Y, **18**M, **18**C, and **18**K are provided in the four containing parts.

The developing units **18**Y, **18**M, **18**C, and **18**K each include a developing roller (not illustrated), and the developing units **18**Y, **18**M, **18**C, and **18**K retain Y, M, C, and K color toners, respectively. A static eliminator/cleaner **22** is provided on the opposite side of the developing device **18** across the photoconductor drum **12**. The static eliminator/cleaner **22** has the function of removing electricity on the periphery face of the photoconductor drum **12** and the function of removing unnecessary toners left on the periphery face of the photoconductor drum **12**.

The image forming apparatus **10** according to the first exemplary embodiment forms a color image while the photoconductor drum **12** rotates four times. That is, during four rotations of the photoconductor drum **12**, the charging roller **14** continues charging the periphery face of the photoconductor drum **12**, and the static eliminator/cleaner **22** continues removing electricity on the periphery face of the photoconductor drum **12**.

The laser beam scanner **16** repeats scanning on the periphery face of the photoconductor drum **12** using a laser beam modulated in accordance with any of pieces of image information of Y, M, C, and K indicating a color image to be formed, while switching image information to be used to modulate a laser beam every time the photoconductor drum **12** rotates once.

Also, while any of the developing units **18**Y, **18**M, **18**C, and **18**K faces the periphery face of the photoconductor drum **12**, the developing device **18** causes that developing unit **18** to operate, develops an electrostatic latent image formed on the periphery face of the photoconductor drum **12** to a particular color, and forms a toner image of the particular color on the periphery face of the photoconductor drum **12**. Every time the photoconductor drum **12** rotates once, the developing device **18** repeats this series of operations while rotating the container in order to switch the developing part used to develop an electrostatic image.

Accordingly, every time the photoconductor drum **12** rotates once, toner images of Y, M, C, and K are sequentially formed on the periphery face of the photoconductor drum **12** so as to overlap one another. At the time the photoconductor drum **12** rotates four times, a color toner image is formed on the periphery face of the photoconductor drum **12**.

An endless intermediate transfer belt **20** is arranged downstream of the photoconductor drum **12**. The intermediate transfer belt **20** is wound on rollers **24**A to **24**D. The intermediate transfer belt **20** is arranged so that its periphery face contacts the periphery face of the photoconductor drum **12**. The rollers **24**A to **24**D rotate in response to transmission of the driving force of a motor (not illustrated), thereby rotating the intermediate transfer belt **20** in a direction indicated by arrow B.

A first transfer roller **26** is arranged on the opposite side of the photoconductor drum **12** across the intermediate transfer belt **20**. The first transfer roller **26** presses the intermediate transfer belt **20** against the periphery face of the photoconductor drum **12**. The image forming apparatus **10** includes a first transfer power supply (not illustrated) for supplying power to the first transfer roller **26** in order to transfer a toner image on the photoconductor drum **12** to the first transfer roller **26**.

Therefore, the first transfer power supply (not illustrated) supplies power to the first transfer roller **26**, and the first transfer roller **26** presses the intermediate transfer belt **20** against the periphery face of the photoconductor drum **12**, thereby transferring a toner image formed on the periphery face of the photoconductor drum **12** to an image forming face of the intermediate transfer belt **20**. When a toner image formed on the periphery face of the photoconductor drum **12** is transferred to the intermediate transfer belt **20**, the static eliminator/cleaner **22** cleans a region of the periphery face of the photoconductor drum **12** which has retained the transferred toner image.

The sheet container **30** is arranged downstream from the intermediate transfer belt **20**. The sheet container **30** contains a pile of many recording sheets P serving as recording media. An extracting roller **32** is arranged above left of the sheet container **30**. Pairs of rollers **34** and **36** are sequentially arranged downstream in a direction in which the recording sheets P are extracted by the extracting roller **32**. In response to rotation of the extracting roller **32**, the top recording sheet P of the pile is extracted from the sheet container **30** and is carried by the pairs of rollers **34** and **36**.

The recording sheet P carried by the pairs of rollers **34** and **36** is fed in between the intermediate transfer belt **20** and a second transfer roller **38**.

A second transfer power supply **28** applies voltage to the roller **24**A, and the second transfer roller **38** and the roller **24**A press the intermediate transfer belt **20** against the recording sheet P, thereby transferring the toner image formed on the image forming face of the intermediate transfer belt **20** to the recording sheet P.

The second transfer power supply **28** generally applies a voltage of about a few thousand volts to the roller **24**A. Therefore, the image forming apparatus **10** according to the first exemplary embodiment connects a protection device **27** to a connection line that connects the second transfer power supply **28** and the roller **24**A.

If the second transfer power supply **28** breaks down and outputs an abnormal voltage that is greater than or equal to a pre-set voltage exceeding a steady-state voltage output in a steady state, the protection device **27** prevents application of the abnormal voltage to a load, such as the roller **24**A or the second transfer roller **38**, connected to the second transfer power supply **28**.

In response to application of abnormal voltage to the protection device **27**, the protection device **27** outputs a control signal to a controller **86** (see FIG. **4**) described later. In response to input of the control signal, output from the protection device **27**, to the controller **86**, the controller **86** stops the abnormal voltage output from the second transfer power supply **28**.

A fixer **40** is arranged downstream from the second transfer roller **38**, in a direction in which the recording sheets P are carried (in a direction indicated by arrow C in FIG. **2**). The fixer **40** includes a heating roller **40**A that heats a toner image on a recording sheet P, and a roller **40**B pressed against the heating roller **40**A. As the recording sheet P passes a nip part between the heating roller **40**A and the roller **40**B, the toner image is melted, solidified, and fixed to the recording sheet P. The recording sheet P is ejected outside the image forming apparatus **10** by a sheet ejection roller (not illustrated) arranged downstream from the fixer **40**, in a direction in which the recording sheet P is carried.

So far, a process of forming an image on a recording sheet P has been described using the image forming unit **54** which uses a rotary developing system (four cycle system) by way of example.

However, the image forming unit **54** according to the first exemplary embodiment may be one that uses the so-called tandem system which arranges photoconductor drums of Y, M, C, and K in series on the intermediate transfer belt **20**, and transfers a toner image on the photoconductor drum **12** to the image forming face of the intermediate transfer belt **20**.

FIG. **3** is a block diagram illustrating the configuration of a major portion of the electrical system of the image forming apparatus **10** according to the first exemplary embodiment. As depicted in FIG. **3**, the image forming apparatus **10** includes a computer **50**.

The computer **50** includes a central processing unit (CPU) **50**A, a read-only memory (ROM) **50**B, a random-access memory **50**C, and an input/output interface (I/F) **50**D, which are interconnected via a bus **50**E.

For example, the image reading unit **52**, the image forming unit **54**, the display operation unit **62**, a sheet feeding unit **70**, a sheet ejecting unit **72**, a hard disk **74**, and a network communication interface (I/F) **76** are connected to the I/O **50**D.

The sheet feeding unit **70** includes, for example, the sheet container **30** which contains the recording sheets P serving as recording media, and a feeding mechanism that feeds the recording sheets P from the sheet container **30** to the image forming unit **54**.

The sheet ejecting unit **72** includes, for example, an ejection part where the recording sheets P are ejected, and an ejecting mechanism for ejecting a recording sheet P on which an image is formed by the image forming unit **54** onto the ejection part.

The hard disk **74** stores, for example, log data such as the operating status of each unit of the image forming apparatus **10**, log data of the result of processing such as copying or printing, various types of setting data, and a control program of the image forming apparatus **10**.

The network communication I/F **76** is an interface for performing mutual data communication with a terminal device such as a personal computer (not illustrated).

A control program of a process described later is stored in advance in, for example, the hard disk **74**, and is read and executed by the CPU **50**A.

Alternatively, a configuration in which the control program is recorded on a storage medium such as a compact disc read-only memory (CD-ROM) or the like, and the control program is read and executed by a CD-ROM drive or the like, or a configuration in which the control program is received via a wired or wireless communication unit and executed may be used.

FIG. **4** is a functional block diagram illustrating the functional configuration of the image forming apparatus **10** according to the first exemplary embodiment.

As depicted in FIG. **4**, the image forming apparatus **10** according to the first exemplary embodiment includes a voltage applying unit **80**, the protection device **27** including a discharge unit **82** and an output unit **84**, the controller **86**, and a reporting unit **88**.

Upon receipt of, for example, a voltage application instruction or a voltage stopping instruction from the controller **86**, the voltage applying unit **80** starts or stops applying voltage to the charging power supply **15**, the first transfer power supply (not illustrated), the second transfer power supply **28**, or the like.

When, for example, the second transfer power supply **28** applies voltage to the roller **24**A, if abnormal voltage is applied due to breakdown of the second transfer power supply **28** or the like, the discharge unit **82** performs discharge and prevents application of the abnormal voltage to the roller **24**A.

The output unit **84** generates a control signal from discharge current that flows during discharge performed by the discharge unit **82**, and outputs the control signal outside the protection device **27**.

The controller **86** controls, for example, the voltage applying unit **80** to perform power supply management of the image forming apparatus **10**. At the same time, the controller **86** controls the reporting unit **88** to report abnormal voltage in case of detection of abnormal voltage.

Although the display **64** is used to display the occurrence of an abnormality in each unit of the image forming apparatus **10** in the first exemplary embodiment, the first exemplary embodiment is not limited to the this case. For example, the occurrence of an abnormality may be reported by sound, or the occurrence of an abnormality may be displayed on a terminal device such as a personal computer (not illustrated) via the network communication I/F **76**.

When a control signal output from the output unit **84** is input to the controller **86**, the controller **86** performs power supply stop control of the voltage applying unit **80**.

There are two types of power supply stop control: overall power supply stop control and individual power supply stop control.

Overall power supply stop control reports a voltage stopping instruction to the voltage applying unit **80**, thereby forcedly stopping the voltage output of all the power supplies included in the image forming apparatus **10** and invalidating the operation of the main power switch **68**.

Individual power supply stop control is the same as overall power supply stop control in the point that all the power supplies included in the image forming apparatus **10** are forcedly stopped by reporting a voltage stopping instruction to the voltage applying unit **80**. However, individual power supply stop control is different in the point that, when the main power switch **68** is turned on again to give an instruction to activate the image forming apparatus **10**, the controller **86** does not activate a power supply that has output the abnormal voltage, but reports a voltage application instruction to the voltage applying unit **80** in order to activate a power supply (not illustrated) for activating at least the display operation unit **62**.

Which type of control is to be used in power supply stop control is pre-set by the administrator of the image forming apparatus **10**, and the setting details are stored in advance in, for example, the hard disk **74**. When a control signal output from the output unit **84** is input to the controller **86**, the controller **86** reads the setting details stored in advance in the hard disk **74** and controls the voltage applying unit **80** in accordance with the setting details.

FIG. **5** is a schematic diagram illustrating the configuration of a major portion of the protection device **27** according to the first exemplary embodiment.

In the protection device **27** according to the first exemplary embodiment, one of a pair of electrodes **27**A with a discharge gap is connected to a connection line that connects the roller **24**A, arranged facing the second transfer roller **38**, and the second transfer power supply **28**. The other one of the pair of electrode **27**A is connected to ground via a pulse transformer T. The output unit **84** which outputs a control signal is electrically insulated by the pulse transformer T from the second transfer power supply **28**.

In response to application of abnormal voltage from the second transfer power supply **28** to the pair of electrodes **27**A due to breakdown of the second transfer power supply **28** or the like, discharge occurs between the pair of electrodes **27**A. Therefore, the abnormal voltage is not applied to the roller **24**A, the intermediate transfer belt **20**, and the second transfer roller **38**, which receive voltage supplied from the second transfer power supply **28**.

When discharge occurs between the pair of electrodes **27**A, a closed circuit that connects the second transfer power supply **28**, the pair of electrodes **27**A, and the pulse transformer T is formed, and current I flows through the closed circuit.

Because one of the pair of electrodes **27**A is connected to a load of the second transfer power supply **28**, the current I flows from the pulse transformer T to the pair of electrodes **27**A in the protection device **27** according to the first exemplary embodiment.

While the current value of the current I flowing through the primary side of the pulse transformer T is changing, induced electromotive force is generated on the secondary side of the pulse transformer T, and current I**1** flows through the secondary side of the pulse transformer T. The current I**1** is converted into voltage by a resistor R and is output as a control signal to the outside of the protection device **27**.

FIG. **6** is a waveform chart of a control signal output from the protection device **27** according to the first exemplary embodiment. The voltage value Vmax of peak voltage of the control signal is adjusted by changing the resistance value of the resistor R included in the protection device **27**.

The voltage value Vmax may be adjusted to be greater than or equal to a voltage value detectable by the controller **86**.

A Zener diode D is connected to an output terminal of the control signal of the protection device **27** in order to electrically protect a circuit of the controller **86** of the image forming apparatus **10**, which receives the control signal.

The pair of electrodes **27**A according to the first exemplary embodiment perform discharge in response to application of a voltage greater than or equal to a pre-set voltage value exceeding a steady-state voltage output by the second transfer power supply **28** in a steady state. The pre-set voltage value at which discharge occurs is set by adjusting the distance between the electrodes of the pair of electrodes **27**A.

FIGS. **7**A to **7**F illustrate examples of the shapes of the electrodes of the pair of electrodes **27**A of the protection device **27** according to the first exemplary embodiment.

As depicted in FIG. **7**A, for example, the shapes of the electrodes of the pair of electrodes **27**A are bulging out in directions facing each other. For example, the tip of each bulging out shape is pointed.

The pre-set voltage value at which discharge occurs is set by adjusting the minimum distance between the electrodes of the pair of electrodes **27**A, that is, a distance d from the tip of the bulging out shape of one electrode to the tip of the bulging out shape of the other electrode. The longer the distance d, the pre-set voltage value at which discharge occurs becomes greater. The shorter the distance d, the pre-set voltage value at which discharge occurs becomes smaller.

Although affected by environmental conditions such as temperature or humidity, the pre-set voltage value at which discharge occurs generally becomes about 3000 V to 4000 V when the distance d is adjusted to about 2 mm to 3 mm.

Although the shapes of the electrodes of the pair of electrodes **27**A according to the first exemplary embodiment are bulging out in directions facing each other, the shapes of the electrodes are not limited to these shapes. For example, as depicted in FIG. **7**B, the shape of one electrode may be bulging out, and the shape of the other electrode may be planar. Alternatively, as depicted in FIG. **7**C, the tips of the bulging out shapes may have an obtuse angle and may be round.

Furthermore, as depicted in FIG. **7**D, the shapes of both the electrodes of the pair of electrodes **27**A may be planar. Alternatively, as depicted in FIG. **7**E, an insulator **90** with the same width as the width in the longitudinal direction of the electrodes may be held between the pair of electrodes **27**A. Alternatively, as depicted in FIG. **7**F, an insulator **92** with a width shorter than the width in the longitudinal direction of the electrodes may be held between the pair of electrodes **27**A.

Referring now to FIG. **8**, the operation of the image forming apparatus **10** when executing power supply stop control according to the first exemplary embodiment will be described.

FIG. **8** is a flowchart illustrating the flow of a process of an image forming program executed by the CPU **50**A of the computer **50** of the image forming apparatus **10**. The program is stored in advance in a predetermined region of the hard disk **74**.

The process of power supply stop control according to the first exemplary embodiment is set in advance by the administrator to perform overall power supply stop control. Power supply stop control is executed by the CPU **50**A while the power of the image forming apparatus **10** is on.

In step S**105**, the process monitors a control signal output from the protection device **27**, which indicates detection of abnormal voltage at the second transfer power supply **28**, and determines whether a control signal is input. When the determination is negative, the process returns to step S**105** and continues monitoring a control signal. When the determination is positive, the process proceeds to step S**110**.

In step S**110**, detection of abnormal voltage at the second transfer power supply **28** is recorded in a predetermined region of the hard disk **74**. The recording destination of detection of abnormal voltage is not limited to this destination, and detection of abnormal voltage may be recorded in a recording device included in a terminal device such as a personal computer (not illustrated) via the network communication I/F **76**.

In step S**115**, the process reads the control type of power supply stop control stored in advance in the hard disk **74**.

In the first exemplary embodiment, the setting of overall power supply stop control is read as the control type of power supply stop control. Thus, the process invalidates the operation of the main power switch **68** from this step onward, and reports a voltage stopping instruction, which stops voltage of all the power supplies included in the image forming apparatus **10**, to the voltage applying unit **80**. Accordingly, the power supplied to the image forming apparatus **10** is forcedly turned off.

Thus, even when the main power switch **68** is turned on after step S**115** is performed, because the main power switch **68** has been invalidated, no power is supplied to the image forming apparatus **10**, and no abnormal voltage is output from the second transfer power supply **28**.

Although the protection device **27** is used to detect abnormal voltage output by the second transfer power supply **28** in the first exemplary embodiment, the first exemplary embodiment is not limited to this case. The protection device **27** may be used to detect abnormal voltage output by another power supply, such as the charging power supply **15** or the first transfer power supply (not illustrated), included in the image forming apparatus **10**.

According to the first exemplary embodiment, the protection device **27** is arranged independent of a power supply or a load that receives voltage supplied from the power supply. When abnormal voltage is applied from a power supply, the protection device **27** performs discharge using the pair of electrodes **27**A, detects discharge current that flows during discharge, and outputs the discharge current as a control signal to the outside.

When a control signal output from the protection device **27** is input to the image forming apparatus **10**, power supplies included in the image forming apparatus **10** are forcedly stopped, and, even when an instruction to activate the image forming apparatus **10** is given, no power is supplied to the image forming apparatus **10** again.

Second Exemplary Embodiment

Next, a second exemplary embodiment of the invention will be described. In the second exemplary embodiment, in addition to the process described in the first exemplary embodiment, detection of abnormal voltage in the image forming apparatus **10** is reported to the user.

Referring to FIG. **9**, the operation of the image forming apparatus **10** when executing power supply stop control according to the second exemplary embodiment will be described.

FIG. **9** is a flowchart illustrating the flow of a process of an image forming program executed by the CPU **50**A of the computer **50** of the image forming apparatus **10**. The program is stored in advance in a predetermined region of the hard disk **74**.

The process of power supply stop control according to the second exemplary embodiment is set in advance by the administrator to perform individual power supply stop control. Power supply stop control is executed by the CPU **50**A while the power of the image forming apparatus **10** is on.

The process illustrated in FIG. **9** is different from the process illustrated in FIG. **8** in the point that the processing in steps S**100**, S**102**, and steps S**120** to S**140** is added. The processing in the other steps is the same as that in FIG. **8**, and descriptions thereof are appropriately omitted.

In step S**100**, the process monitors the selection status of the main power switch **68** to determine whether the main power switch **68** is turned off. When the determination is negative, the process proceeds to step S**105**. When the determination is affirmative, the process proceeds to step S**102**.

In step S**102**, the process executes a predetermined process upon stopping of the power supply, which is executed when the main power switch **68** is turned off, such as recording various types of data on the RAM **50**C in a predetermined region of the hard disk **74**.

In steps S**105** and S**110**, the process executes the same processing as that in the first exemplary embodiment.

When the determination in step S**105** is negative, the process returns to step S**100**.

In step S**120**, the process reads the control type of power supply stop control, which is stored in advance in the hard disk **74**.

In the second exemplary embodiment, the setting of individual power supply stop control is read as the control type of power supply stop control. Thus, the process reports, to the voltage applying unit **80**, a voltage stopping instruction that stops voltage of all the power supplies included in the image forming apparatus **10**. Accordingly, the power supplied to the image forming apparatus **10** is forcedly turned off.

In step S**125**, the process determines whether the main power switch **68** is turned on. When the determination is negative, the process enters standby until the main power switch **68** is turned on. When the determination is affirmative, the process proceeds to step S**130**.

In step S**130**, the process reads the data in the predetermined region of the hard disk **74**, which has been written in step S**110**, and determines whether detection of abnormal voltage at the second transfer power supply **28** is recorded. When the determination is negative, the process proceeds to step S**132**. When the determination is affirmative, the process proceeds to step S**135**.

In step S**132**, since there is no abnormality in the second transfer power supply **28**, the process enters standby until a print instruction is given from the user.

In step S**135**, the process reports a voltage application instruction to the voltage applying unit **80** in order to activate power supplies other than the second transfer power supply **28** included in the image forming apparatus **10**, such as a driving power supply (not illustrated) of the display **64** of the display operation unit **62**. Therefore, the second transfer power supply **28**, which is not included in the voltage application instruction, will not be activated.

In step S**140**, the process controls the reporting unit **88** to display, on the display **64**, the occurrence of an abnormality in the second transfer power supply **28**, thereby prompting the user to call for a serviceman to do maintenance of the image forming apparatus **10**.

Note that the method of reporting a power supply abnormality is not limited to the above method. For example, a power supply abnormality may be reported by sound, or the fact that the power supply broke down may be displayed on a terminal device such as a personal computer (not illustrated) via the network communication I/F **76**.

According to the second exemplary embodiment, in response to turning on of the main power switch **68**, power supplies other than a power supply that has output abnormal voltage are activated. In this way, the operating status of the image forming apparatus **10** is reported to the user.

Although the exemplary embodiments of the invention have been described as above, the technical scope of the exemplary embodiments is not limited to that described in the foregoing exemplary embodiments. Various changes or improvements can be added to the foregoing exemplary embodiments without departing from the gist thereof. The exemplary embodiments with these changes or improvements are also included in the technical scope of the exemplary embodiments.

Although the case in which the power supply stop control of the image forming apparatus **10** is realized by a software configuration has been described in the foregoing exemplary embodiments, the exemplary embodiments are not limited to this case. For example, the power supply stop control may be realized by a hardware configuration.

An exemplary embodiment in this case generates and uses, for example, a functional device that executes the same processing as that executed by the controller **86**. In this case, the speed of processing is expected to be faster, compared with the above-described exemplary embodiments.

Although the protection device **27** according to the exemplary embodiments is arranged in the body of the image forming apparatus **10**, the protection device **27** may be arranged outside the body of the image forming apparatus **10**.

In this case, compared with the above-described exemplary embodiments, the voltage value Vmax is expected to be easily adjusted by changing the resistance value of the resistor R of the protection device **27**.

Although the protection device **27** is applied to the image forming apparatus **10** in the foregoing exemplary embodiments, the scope of application of the protection device **27** is not limited to that described above. For example, the protection device **27** may be used in an electronic device, such as a television, which may output abnormal voltage when its power supply breaks down.

The foregoing description of the exemplary embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, thereby enabling others skilled in the art to understand the invention for various embodiments and with the various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.

What is claimed is:

1. A protection device comprising:

a pair of electrodes in which one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, is configured to perform discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state; and

an output unit configured to detect discharge current that flows in the other electrode and output the detected discharge current as a control signal,

wherein the distance between the pair of electrodes is adjusted in accordance with the voltage value of the pre-set voltage.

2. The protection device according to claim **1**, wherein the shape of at least one electrode of the pair of electrodes is bulging out toward the other electrode facing the at least one electrode.

3. The protection device according to claim **1**, wherein an insulator is held between the pair of electrodes.

4. The protection device according to claim **2**, wherein an insulator is held between the pair of electrodes.

5. An image forming apparatus comprising:

a protection device according to claim **1**; and

a controller configured to control, in response to input of the control signal, the power supply not to supply voltage to the load even when an instruction is given to activate the power supply.

6. The image forming apparatus according to claim **5**, further comprising a reporting unit configured to report information relating to an operating status,

wherein the controller is configured to control, in response to input of the control signal, the reporting unit to report the occurrence of an abnormality in the power supply.

7. A non-transitory computer readable medium storing a program causing a computer to execute an image forming process, the process comprising:

detecting discharge current that flows in, of a pair of electrodes in which one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, performs discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state, the other electrode and outputting the detected discharge current as a control signal; and

controlling, in response to input of the control signal, the power supply not to supply voltage to the load even when an instruction is given to activate the power supply.

8. An image forming method comprising:

detecting discharge current that flows in, of a pair of electrodes in which one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, performs discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state, the other electrode and outputting the detected discharge current as a control signal; and

controlling, in response to input of the control signal, the power supply not to supply voltage to the load even when an instruction is given to activate the power supply.

9. A protection device comprising:

a pair of electrodes in which one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, is configured to perform discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state; and

an output unit configured to detect discharge current that flows in the other electrode and output the detected discharge current as a control signal,

wherein the shape of at least one electrode of the pair of electrodes is bulging out toward the other electrode facing the at least one electrode.

10. An image forming apparatus comprising:

a protection device comprising:

a pair of electrodes in which one electrode, connected to a connection line that connects a load and a power supply that supplies voltage to the load, is configured to perform discharge toward the other electrode in response to application, to one electrode, of an abnormal voltage greater than or equal to a pre-set voltage exceeding a steady-state voltage output by the power supply in a steady state; and an output unit configured to detect discharge current that flows in the other electrode and output the detected discharge current as a control signal; and

a controller configured to control, in response to input of the control signal, the power supply not to supply voltage to the load even when an instruction is given to activate the power supply.

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